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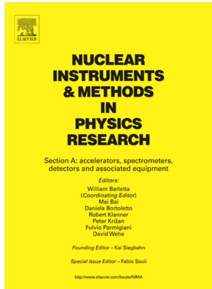


RICH detectors: Analysis methods and their impact on physics

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# RICH detectors: analysis methods and their impact on physics

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**Abstract**

The paper discusses the importance of particle identification in particle physics experiments, and reviews the impact of ring imaging Cherenkov (RICH) counters in experiments that are currently running, or are under construction. Several analysis methods are discussed that are needed to calibrate a RICH counter, and to align its components with the rest of the detector. Finally, methods are reviewed on how to employ the collected data to efficiently separate one particle species from the other.

*Key words:* Ring imaging Cherenkov counter, RICH, proximity focusing, Belle II, LHCb, HERA-B, Aerogel, focusing radiator
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## 1. Introduction

Reliable particle identification methods have by now become an indispensable part of detectors in particle physics. To list a few examples: tagging of $B$ meson flavour with the kaon charge in the CP violation measurements in the $B$ system, study of rare $B$ and $D$ meson decays, hadron identification in the studies of the quark-gluon plasma, in searches for exotic hadrons, and in studies of the nucleon structure. Charged particles are identified either by the way they interact (e.g., in calorimeters and muon detectors) or by measuring their mass. The mass is, in turn, determined by combining the measurements of momentum and velocity. Since in a typical particle physics experiment particle momentum is inferred from the measured radius of curvature in a magnetic field, the remaining issue is to measure the velocity with sufficient precision. This is either achieved by measuring the time-of-flight, ionization losses or Cherenkov angle of the particle. In the present contribution analysis methods for imaging Cherenkov counters are discussed, together with their impact on physics studies.

The structure of the paper is as follows. We first discuss the importance of particle identification in particle physics experiments, and review the impact of ring imaging Cherenkov (RICH) counters in experiments that are currently running, or are under construction. We then discuss a number of analysis methods that are needed to calibrate and align the components of a RICH counter with the rest of the detector, as well as the methods on how to employ the recorded hit patterns to efficiently separate one particle species from another.

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## 2. Impact of Cherenkov counters on physics analyses

Cherenkov detectors have become an essential tool in particle physics experiments because of their ability to provide particle identification over very large kinematic regions. With a single RICH detector it is possible to cover a factor of about 10 in the ratio between the highest and the lowest particle momentum; by combining two or more radiators this range can be considerably extended [1]. In neutrino physics experiments, Cherenkov detectors do not only provide a means to separate final state electrons from muons in neutrino mixing experiments, they are also essential as the neutrino target medium [2]. To further illustrate the importance of this detection method we note that two out of three recent discoveries in particle physics that were distinguished by a Nobel Prize got essential experimental support from Cherenkov detectors.

Cherenkov detectors have been of particular importance in flavour physics since the pioneering OMEGA, DELPHI and SLD experiments. Particle identification with Cherenkov detectors at $B$ factories, Belle and BaBar [3–5], was essential for the observation of CP violation in the $B$ meson system, both in tagging the flavour of the $B$ mesons as well as for the reconstruction of few-body decays like $B \to \pi^+\pi^-$ and $B \to K^+\pi^-$.